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To : Tom Walker

From : Stephen H. Kaiser

Correction to Earlier Calculation & Formulation of General Equations : Breakeven Point for Table 6-1 Manomet Report : Biomass vs. Fossil

In my July 9 comment letter to DOER, I considered the basic question that Manomet was assigned. How does the burning of biomass compare with other fossil fuels, for the years 2050 and thereafter, in terms of carbon emissions and forest regeneration? I asked the question : did Manomet properly evaluate the climate change implications of biomass power generation?

My conclusion was that Manomet and probably the entire profession of climate change analysis has been using the wrong criterion to evaluate initial carbon debt followed by mitigating tree growth. My proposal for an alternate measurement method centered on a cumulative assessment of carbon levels over time and the duration of these changes during the time span under consideration. Manomet and others may have made an error in considering only the carbon accumulations at the end of a given period of time. The mistake is not in mathematics but in assessing climate change impacts. I made a distinction between end-point and duration impacts.

One new problem I noticed is that I made a mathematical mistake in my own formulation. Your method allowed a simple summation of impacts from Table 6-1 over a period of years. I was attempting a piecewise integration -- a step-by-step, decade-by-decade integration over nine decades, and that was a bit crude in terms of mathematical accuracy. I think the correct answer is 100 years for equivalence of biomass and fossil fuel, not 90 years.

I found the mistake by doing a check at a finer level of integration, using 100 steps or area slices under the curve. That gave me 99.5 years and I knew something was wrong. So I started to see if I could find a finer integration or a formula that would give me a more exact result.

I wanted to calculate the total amount of carbon exposure in the atmosphere, and its relation to amount in tons and a span of years. I assumed that the relation between temperature change and carbon change was the same constant for both biomass and fossils fuels in the Table 6-1 example. This ratio I called T/C.

The carbon exposure with biomass combustion is $D_b * Y$, where D_b is the initial biomass debt of 15 tons and Y is the number of years of exposure. For 100 years, the biomass exposure is 1500 ton-years. Every year of biomass growth is an opposing increment that reduces the debt and net exposure. A biomass growth in the 25th year would have an exposure time of 100 - 25 or 75 years. In adding up the total exposure after 100 years, I would have the initial debt followed by 100 additions for a temperature impact with each element having the form :

$$T/C * G_b * (Y-x)$$

where G_b is the annual biomass rate of tree growth in tons per year or 0.25 tons per year

x is the number of years into the future.

The term Y-x would vary from 0 to 100 years so average years of impact would be Y/2. The number of additions would be Y or 100. The temperature change for the biomass options becomes

$$\Delta T_b = T/C\ (-D_b * Y + G_b * Y * Y/2)$$

The equivalent temperature change for fossil fuel operation is :

$$\Delta T_f = T/C\ (-D_f * Y + G_f * Y * Y/2)$$

where D_f is the initial carbon debt from fossil fuel combustion = 10 tons

G_f is the annual fossil rate of tree growth in tons per year or 0.15 tons per year

Temperature change impacts for the two options would be equivalent when the two equations are the same :

$$T/C\ (-D_b * Y + G_b * Y * Y/2) = T/C\ (-D_f * Y + G_f * Y * Y/2).$$

This equation can be simplified to the year Y_e of Equivalence :

$$Y_e = -2\ (D_b - D_f) / (G_b - G_f)$$

From Table 6.1, the initial debt difference is -5 tons and $G_b - G_f$ becomes 0.25 - 0.15 = 0.1 tons per yr. The equivalent time Y_e is 100 years. It is clear that a temperature-based assessment gives us a result which is twice that of the simple carbon-based evaluation. Now we have an algebraic formula that works.

By the way, your formula for carbon is :

$$Y_e = -(D_b - D_f) / (G_b - G_f) = 50 \text{ years.}$$

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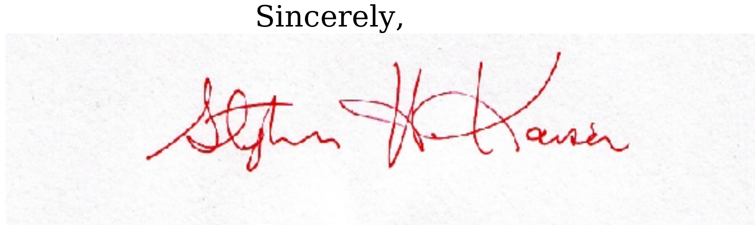
Sincerely,



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cc. David Cash
Robert O'Connor